 0030-0950/84/0001-0016 $2.00/0

BIOMASS EQUATIONS FOR SOUTHEASTERN OHIO FOREST TREES[1]

JOSEPH D. KASILE, Division of Forestry, The Ohio State University, 2021 Coffey Rd., Columbus, OH 43210

ABSTRACT. Biomass equations for total tree weight above stump were developed for 8 Ohio forest tree species or species groups. Of the predictor variables tested by multiple linear regression, diameter squared at 1.4 m above ground (d.b.h.) was the most consistent significant variable. R^2 for the species ranged from 0.80 to 0.96. Species equations were not significantly different. The combined equation for all species was: Total green weight, kg $= -100.3 + 0.9628$ (Diameter, cm at 1.4 m above ground)^2.

OHIO J. SCI. 84 (1): 16–18, 1984

INTRODUCTION

The introduction of whole-tree chippers into the logging industry in Ohio necessitates the development of biomass equations reflecting biomass for all of the above-stump portion of trees, including twigs, branches, bark, and main stem. Previous to the introduction of whole-tree chippers, up to 50% of the tree by weight was left unutilized in the forest (Steve Brown, Mead Corp., Chillicothe, OH, pers. comm.).

Methods for estimating forest tree biomass by weight in Ohio presently are based on previous utilization standards or by using biomass equations developed for other parts of the country (Brenneman et al. 1978, Wiant et al. 1977). Equations developed for other areas are based on different growing conditions and may be inappropriate for application in Ohio.

This study developed fresh weight equations for the biomass of major forest species of Ohio. Harvesting was done with a whole-tree chipper operation to duplicate the utilization methods of the logging industry.

STUDY SITES

Eleven whole-tree chipper harvesting operations conducted by 7 different operators were sampled during the summer logging seasons of 1979 and 1980. These sites were located in the non-glaciated region of southeastern Ohio, east of U.S. Rt. 70 and south U.S. Rt. 33.

At each location, site index was determined by stem analysis curves of total tree height over total tree age for dominant and codominant crown class trees. The site index number determined from the curves is the total height of the dominant/codominant tree at age 50, with higher site indexes indicating more productive forest growing conditions. The closer the tree age is to the base age of 50 years, the more reliable is the site index estimate. Carmean's curves (1978) were used to determine site quality for 13 tree species. Since each tree species has its own individual growth characteristics, site indexes of these various tree species were converted to those of black oak (*Quercus velutina* Lam.) providing for comparisons between locations (Carmean 1979). The black oak site indexes for each location then were averaged. These averages ranged from a low of 52 to a high of 73 for the 11 sites.

METHODS AND MATERIALS

At each of the 11 whole-tree chipper logging locations, trees from 12.7 to 55.9 cm in diameter at 1.4 m above ground on the uphill side were selected randomly for sampling. Sampling intensity at each location was 1:80, thus number of trees sampled at each location was proportional to the number of trees harvested at that location (table 1). Species were sampled relative to their frequency in the forest stand.

The lack of adequate sample sizes for some species due to their relative infrequency in the natural

[1]Manuscript received 5 November 1982 and in revised form 11 February 1983 (#82–34).

TABLE 1

Site characteristics of 11 whole-tree sample locations.

Location	Sample Trees	Tree Diameter at 1.4 m (cm.) Min.	Max.	Aver.	No. of Site Index Trees	Average Age for Site Index Trees	Black Oak Site Index Min.	Max.	Aver.
A	30	15	54	36	22	69	63	78	73
B	14	16	47	38	9	58	60	76	71
C	18	13	50	42	12	63	60	78	70
D	14	18	48	36	11	66	61	77	68
E	24	13	54	40	16	74	58	88	67
F	7	17	54	45	5	72	61	70	66
G	12	16	42	35	7	59	53	77	66
H	8	15	46	37	7	43	59	69	64
I	12	14	51	41	6	60	53	69	62
J	9	20	54	40	6	47	51	66	59
K	15	17	44	32	14	59	46	60	52
Average				40					67
Total	163				115				

stands required that, for purposes of analysis, some species be grouped. The red oak group included northern red oak (*Q. rubra* L.) and pin oak (*Q. palustris* Muenchh.). The white oak group included white oak (*Q. alba* L.), bur oak (*Q. macrocarpa* Michx.), and post oak (*Q. stellata* Wangenh.). The hickory group included shagbark hickory (*Carya ovata* (Mill.) K. Koch), mockernut hickory (*C. tomentosa* Nutt.), pignut hickory (*C. glabra* Mill.), bitternut hickory (*C. Cordiformis* Wang.), and shellbark hickory (*C. laciniosa* Michx.). Other species measured were black oak (*Q. velutina* Lam.), chestnut oak (*Q. montana* Willd.), yellow-poplar (*Liriodendron tulipifera* L.), sugar maple (*Acer saccharum* M.), and red maple (*A. rubrum* L.). Two American basswoods (*Tilia americana* L.) and one hackberry (*Celtis occidentalis* L.) were measured in the sample but were subsequently not used in the analysis because of their low sample number. Total numbers of each species or species group are given in table 2.

As a tree was sampled it was numbered with tree marking paint on 3 sides of the main stem. Diameter at 1.4 m was taken on the tree. The tree was then cut at the stump and a steel tape was used to determine to the nearest 30 cm the tree total height, height above ground to live crown, crown length, and crown width.

During the normal course of harvesting at each location, sample trees were pulled to the whole-tree chipper along with the unnumbered trees. At that point each tree was cabled to an electronic load cell and raised clear of the ground by a knuckle-boom loader. The load cell was calibrated monthly during the study period and was never found to be out of adjustment. The load cell registered weights to the nearest 4.5 kg. Total tree weight ranged from 109 to 2186 kg.

RESULTS

The following variables were tested using maximum R^2 regression analysis (SAS 1980): tree species, diameter (at 1.4 m.), total tree height, height to live crown, crown length, crown width, crown length times crown width, height to live crown/total tree height, diameter squared, and diameter squared times total tree height.

Diameter squared was the most significant ($P > 0.05$) variable for each of 5 species. One species had diameter squared times total tree height as the most significant variable and total height was the most significant variable for 2 other species. For these latter 3 species, hickory, sugar maple, and red maple, regression equations were computed using only diameter squared, and the R^2 was reduced from .92 to .90 for hickory, from .91 to .88 for sugar maple, and from .954 to .952 for red maple. Since these reductions were relatively small, only diameter squared was used to develop prediction equations (table 2). No other variables were significant. Using an overall test for coincidental regressions (Zar 1974) the F-test was not rejected ($P = .11$), thus all species can be represented by the single species equation shown in table 2.

TABLE 2
*Weight prediction equations**.

Species	a	b	R^2	n	DBH Range (cm)
Red Oak	23.6	0.8277	.68	30	13–50
White Oak	−190.8	1.1072	.80	25	18–52
Chestnut Oak	− 92.0	0.9472	.84	29	13–55
Yellow Poplar	−307.6	1.0749	.89	10	26–46
Hickory	−105.3	1.1486	.90	16	18–43
Black Oak	−110.1	0.9796	.82	19	13–51
Sugar Maple	− 93.4	0.9553	.88	13	13–54
Red Maple	− 55.0	0.7985	.95	16	15–41
All Species	−100.3	0.9628	.81	163	13–55

*Weight (kg) = a + b [DBH (cm)]^2. To convert to pounds for WT and inches for DBH multiply the slope coefficient by 14.19 and multiply the intercept by 2.2.

Figure 1 shows the weight-d.b.h. relationships based on the equation for each species and the combined equation.

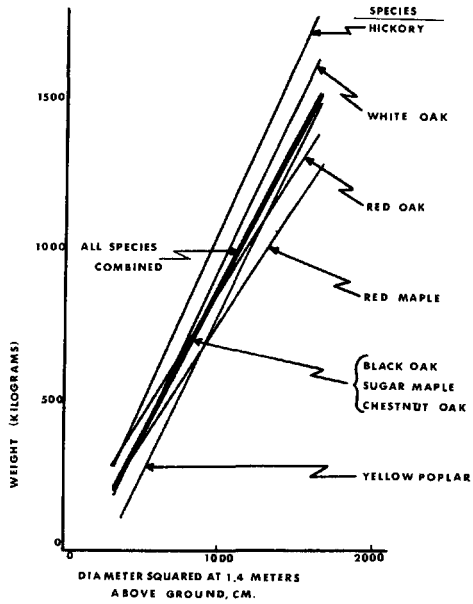

FIGURE 1. Total weight prediction equations.

DISCUSSION

Individual species or species group equations for determining forest tree biomass weight were not significantly different from one another using diameter squared at 1.4 m. In only 3 of the 8 species or species groups were other independent variables significant, and increases in R^2 for those 3 regressions were not considered of practical importance.

The study used field procedures that followed actual field harvesting and utilization standards of the forest logging industry. These results are thus applicable to whole-tree chipper harvesting operations in southeastern Ohio.

When harvesting only a single species or species group, the individual equation for the species or species group is recommended. However, when working with mixed species stands, the all-species equation should be satisfactory as the individual regression equations were not significantly different.

ACKNOWLEDGMENTS. I appreciate the assistance of Robert Brisbin, U.S. Forest Service, of Robert Nelson and his staff, Mead Corporation, and of the 7 whole-tree chipper operators who assisted in the collection of this data. This study was sponsored by the U.S. Forest Service Cooperative Research Agreement No. 23-117. Susan Allen typed the manuscript. Salaries and research support provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. Journal Article No. 165–82.

LITERATURE CITED

Brenneman, B. B., J. D. Frederick, W. E. Gardner, L. H. Schoenhofer and P. L. Marsh 1978 Hardwoods. *In*: P. E. Pope, (ed.), Central hardwood forest conference, proc. of the 2nd meeting, Purdue Univ., p. 159–178.

Carmean, Willard H. 1978 Site index curves for northern hardwoods in northern Wisconsin and upper Michigan. U.S.D.A. Forest Service Research Paper NC-160. 16 p.

——— 1979 A comparison of site index curves for northern hardwood species. U.S.D.A. Forest Service Research Paper NC-167. 12 p.

Statistical Analysis System 1980 SAS Institute Inc., Box 8000, Cary, NC 27511.

Wiant, H. V., Jr., C. E. Sheetz, A. Colorinno, J. C. DeMass and F. Castaneda 1977 Tables and procedures for estimating weights of some Appalachian hardwoods. West Virginia Univ. Agr. and Forest. Exp. Sta., Bull. 659 T.

Zar, J. H. 1974 Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ. 620 p.